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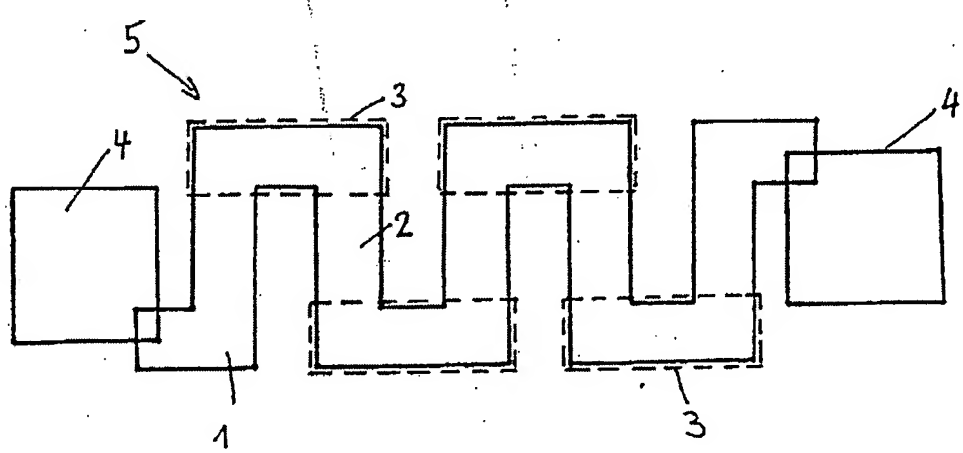
(54) Title: THERMOGENERATOR



(57) Abstract

A thermogenerator (5) comprises n and p thermoelements (1, 2) applied to a substrate by thin and thick-film technology. To reduce the total resistance, additional layers (3) are provided and surfaces (4) are provided for bonding purposes.

THERMOGENERATOR

The invention relates to a thermogenerator comprising p and n elements for a watch, a sensor, a power supply unit or the like, which is located between hot and cold temperature sources, whereby the thermocouples are applied to a substrate with a thin or thick film technology and the shape of the n and p elements is selected so that they intersect one another.

A known thermogenerator is described in CH 604249. This thermogenerator is composed of discrete components formed by cutting thermoelectric material into bars and then reassembling them into blocks. Only a few hundred thermoelectric elements can be connected in series in one watch by this method. The output voltage is too low to supply electric power to a battery. The power must be brought to a level suitable for charging a battery by a complex electronic system and a transformer.

GB 1,381,001 A describes the production of a thin-film thermogenerator on an aluminum and aluminum oxide substrate. This production is suitable for only a very small number of thermocouples. Furthermore, production of the substrate is very complex.

US 3,684,470[1] A describes a Peltier element for heating or cooling a part, wherein the p and n elements are mutually overlapping, and a material that has good electric conductivity but no thermal conductivity is provided between the overlaps.

In the production of thin or thick layers, however, it is important to select a material that bonds the p and n elements, so that it metallurgically yields a compound having good adhesion, a low electric resistance and a good thermal conductivity.

The layers, which are applied by a thin-film technology as described in JP 61 259 580 A and US 4,677,416 A, overlap mutually. Since this always involves only a few pairs, the size of the total electric resistance is no problem. However, such an embodiment is not conceivable in a series circuit of several thousand pairs of elements because the electric resistance would be much too high. In addition, the intermetallic problems at the metal junctions were disregarded.

US 3,554,815 A describes an approach in which the p layer is applied to one side of a substrate and the n layer is applied to the other side. However, this would be far too expensive for mass production. The 5:1 ratio between the layer thickness and the substrate thickness, which is given

[1] TN: The Search Report and Annex give this as US 3,6<u>48</u>,470 A.

in the patent claim, would not be feasible with thin layers. Instead, a ratio of 1:1 is given for the applications described below.

Therefore, the object of the present invention is to produce a thermogenerator that can be manufactured inexpensively, with simple means and in large-scale production.

This is achieved according to the characterizing parts of Patent Claims 1 and 4.

Production on the thermogenerator requires only a mask, which is rotated by 180° after production of the p elements, for example, to then apply the n elements. This automatically results in overlapping of n and p materials. In order for the electric resistance to be reducible, an additional layer of a material that bonds metallically to the n and p materials of the thermocouples must be applied. This does not affect the thermoelectric voltage of the generator but it does greatly improve the efficiency due to this reduction in electric resistance. At the same time, contact surfaces are applied in the same operation and using the same materials, so that the first and last elements of the thermogenerator can be connected to a circuit. Another problem is the heat transfer from the heat sources to the substrate. Due to the application of an additional layer, as described in Patent Claim 4, it is possible to establish optimal heat transfer by using a suitable thermal conduction paste or the like. Since the heat transfer losses through the substrate, the mount and air are not insignificant, this approach to achieving the object is extremely important.

The layer for improving the heat transfer may advantageously be made of the same material as that used for the contact surface or for the additional conducting layers. One of the most important sources of heat transfer loss is determined by the distance between two sources. Air transfers heat relatively well, and there may be a large volume between sources. To reduce this loss, it is advantageous to apply plastic films to the surfaces that come in contact with air to reduce the heat transfer between these sources and air.

The proposed approaches are very effective, especially in a watch, where the temperature difference between the two temperature sources is low, e.g., 3-5°C. When using a thermogenerator in a watch, the watch mechanism is usually round. In the case of a rectangular watch face, it is advantageous to accommodate the thermogenerator in the four corners. In a thin-film generator, approx. 1000 pairs of elements are connected in series; series-connected 4000 pairs thus yield a total voltage of approx. 1.5 volt to charge a battery or a capacitor with a

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capacitance of approximately 1 F. A thermogenerator with 1000 pairs is approx. 30 cm long, so it must be rolled up to allow it to be incorporated into a watch.

The thin films can be produced by vapor deposition, cathode sputtering or flash vaporization. In the case of thick films, screen printing or another printing method may be used. If a thermal treatment is necessary after applying the thermoelectric elements, it is advantageous to use mica or a ceramic as the substrate. Otherwise, a plastic of the polyimide type or polyterephthalate is preferred; such products are available commercially under the brand names Kapton or Mylar. A limited thermal treatment is also possible with these materials. The thickness of the substrate should preferably be thin to minimize the risk of a thermal short circuit. Thermal efficiency is improved when thermoelectric elements are applied to both sides of the substrate.

Instead of using a mask, the thermoelectric material may also be applied to the entire substrate. The desired geometry can be achieved by chemical etching or by using an ion beam.

The n and p thermocouples may be produced from known materials, e.g., Bi, Te, Sb, Se or Pb, Se or Pb, Te or other alloys.

In a thermoelectric watch, the substrate may be arranged around the watch mechanism or the individual substrates may be accommodated at advantageous locations in the watch face.

The electric current of the thermogenerators may charge a capacitor or a battery directly. The battery has the great disadvantage that it contains an electrolyte. This makes it difficult to keep a battery impervious over a long period of time. With today's electrolytes KOH and NaOH, it is practically impossible to keep a battery impervious for at least ten years. These disadvantages do not exist with a capacitor.

In addition to the use of the inventive thermogenerator in a watch, it may also be used in sensors, power supply units, etc. Due to the energy saving measures required in heating, it is advantageous to measure the heat flow. A thermogenerator generates enough electric power and voltage to supply an electronic circuit, and an integrator can measure the quantity of heat, which can then be stored in an electronic memory. The use of a lithium battery, which must also be replaced periodically, is superfluous here.

Such sensors can be used in large-scale heating systems and residential rentals, but they may also be used in industrial plants for fully automatic monitoring of temperature processes, which must function independently of the line voltage or a battery.

An exemplary embodiment of the invention is illustrated in the figures, in which:

Figures 1a and 1b show the n and p elements individually,
Figure 2 shows a thermogenerator having contact faces,
Figure 3 shows an installed thermogenerator,
Figure 4 shows a substrate with a thermogenerator.

Figure 1a shows n elements produced using a mask, and Figure 1b shows the p elements produced using the same mask, but after rotating the latter by 180°. If the n and p elements 1, 2 are now applied to a substrate in the same location, this yields a thermogenerator like that illustrated in Figure 2. To reduce the electric resistance of the thermogenerator 5, additional layers 3 are applied to the contact surfaces of the n and/or p elements. The contact surfaces 4 are applied using the same alloy as the layers 3. These layers 3 and the contact surfaces 4 are made of a material which is metallically soluble with the n and p elements 1, 2. With the contact surfaces 4, it is possible to connect the thermogenerator 5 to an electric circuit.

Example of use in a watch:

Dimensions of a p or n element:

Layer thickness: 0.005 mm, layer width: 0.1 mm, layer length: 0.75 mm, specific electric resistivity: 0.00001 Ω·m. This yields an electric resistance of 30 Ω per pair of elements. With 7500 series-connected pairs of elements, the resistance is 225 kΩ. This resistance can be reduced by 2-4% by using additional layers. A terminal voltage of approx. 1.6 V can be expected at a temperature difference of 6°C. Such a generator can emit a power of 11 microwatts.

It is also conceivable for the thermocouples to be accommodated a watch band having a surface that is thermally insulated with the respective to the arm [of the wearer]. The thermogenerator is then connected via electric leads to the capacitor or the battery of the watch. Instead of a watch, a portable instrument would also be conceivable such as a pulse monitor, a blood pressure monitor, an electronic altimeter, thermometer, electronic compass, etc.

Figure 3 shows a thermogenerator 5 arranged between the two temperature sources 7. To optimize the heat transfer, a material 6 is applied between the temperature sources 7 and the thermogenerator 5. This material must conduct heat as well as possible to promote the transfer of heat from the sources 7 to the thermogenerator 5. This material may be an elastomer in a soft or hardened state and may also contain a relatively large amount of powder that conducts heat well.

In the case of a thermogenerator, as much heat as possible should flow through the thermocouples 1, 2. To achieve this, losses should be minimized through parallel heat bridges. Heat loss through air plays an important role here. This heat loss can be reduced by applying additional films [illeg.; 6?] to one or both temperature sources 7.

Figure 4 is a substrate 10 to which thermocouples 1, 2 have been applied. In addition, a layer 9, which does not come in contact with the thermocouples 1, 2, has also been applied. This layer 9 may be made of metal or of the same material as the connecting layers 3. This layer 9 has the advantage that it improves the transfer of heat from the sources 7, between which the heat transfer material 6 is already present.

Patent Claims

1. Thermogenerator having p and n elements for a watch, a sensor, a power supply unit and the like, arranged between a hot temperature source and a cold temperature source, wherein the thermocouples are applied to a substrate by using a thin-film or thick-film technology, and the shape of the n and p elements is selected so that they intersect one another, characterized in that an additional electrically conducting layer is applied to the p and/or n element(s) to reduce the electric resistance of the thermogenerator, and the first and last elements connected in series are in turn connected to a contact surface.

2. Thermogenerator according to Claim 1, characterized in that the conducting layer and/or the contact surface is/are made of a metal or an alloy which is metallically soluble with the material of the elements.

3. Thermogenerator according to Claim 1 or 2, characterized in that the substrate is coated with thermocouples on both sides.

4. Thermogenerator with p and n elements for a watch, a sensor, a power supply unit or the like which is arranged between a hot and cold temperature source, whereby the thermocouples are applied to a substrate by a thin-film or thick-film technology, characterized in that the heat flow between the two sources is passed at least partially over additional heat bridges.

5. Thermogenerator according to Claim 4, characterized in that the heat bridge made of a thermally conducting, electrically insulating material such as an elastomer to which a thermally conducting powder has been added is applied between the sources and the substrate and/or a heat bridge made of a metal is applied to the substrate in parallel with the longitudinal direction of the substrate to improve the transfer of heat between the sources and the thermocouples.

6. Thermogenerator according to any one of Claims 1 through 5, characterized in that insulation films are applied to the sources to reduce the heat loss through the air.

7. Watch having a thermogenerator according to any one of Claims 1 through 7, characterized in that one or more substrates are arranged around the watch mechanism or several substrates are distributed around the watch mechanism and electrically connected to one another.

8. Watch according to Claim 7, characterized in that the substrate(s) is/are rolled up.

9. Watch according to Claim 7 or 8, characterized in that it is equipped with a capacitor which can be charged by the thermogenerator and supplies electric power to the watch mechanism.

10. Sensor having a thermogenerator according to any one of Claims 1 through 6, characterized in that an integrator is provided to measure the quantity of heat.

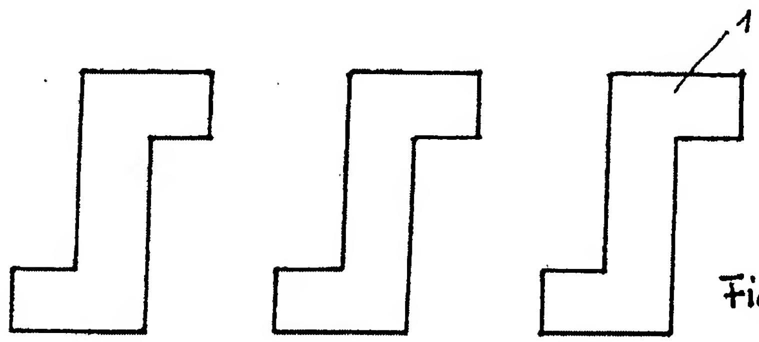

Fig 1a

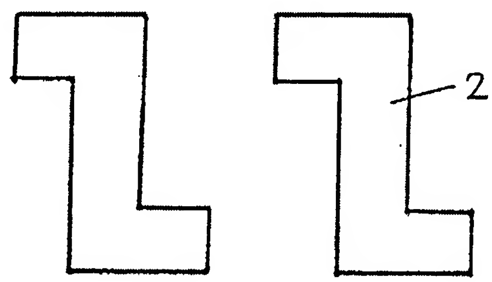

Fig 1b

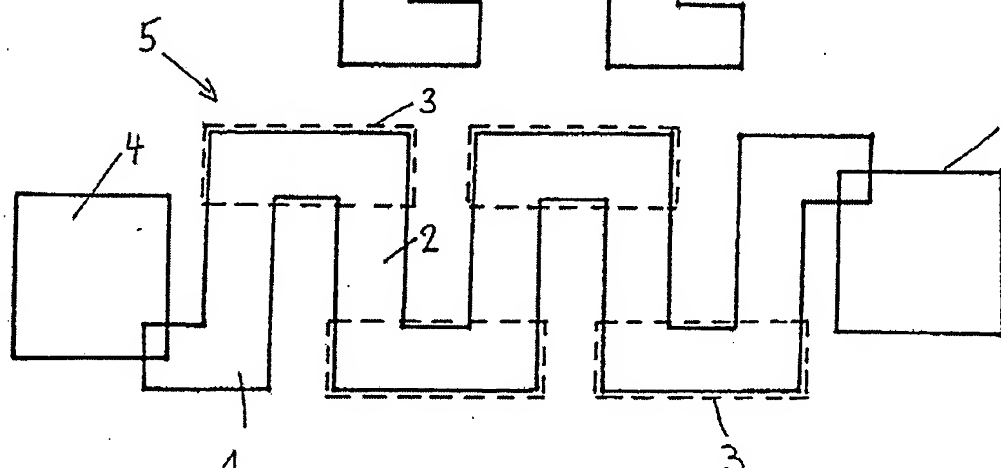

Fig 2

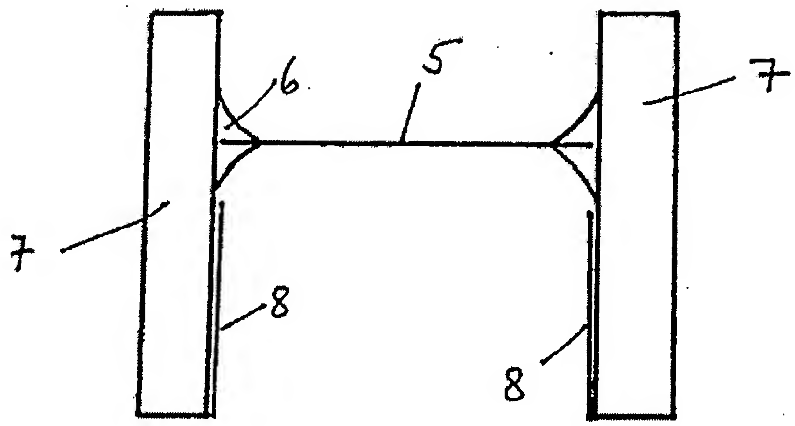

Fig 3

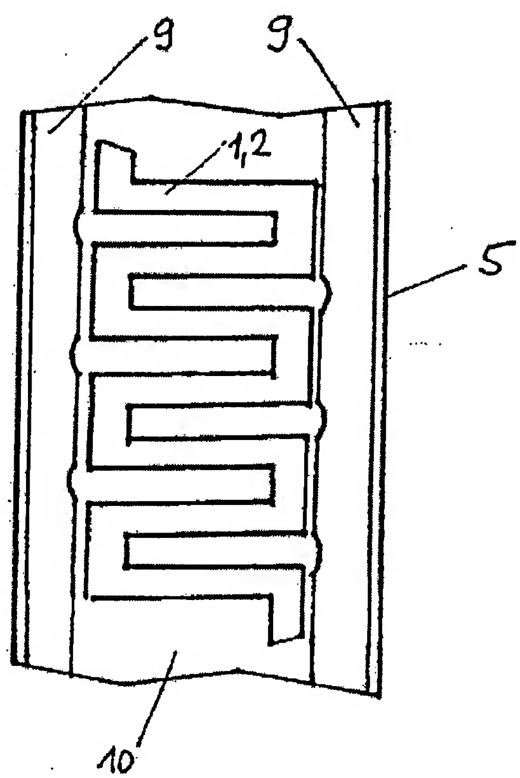

Fig 4

INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 89/00152

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl[4]: H 01 L 35/08

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
Int.Cl[4]	H 01 L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y A	GB,A,1381001 (SENSORS) 22 January 1975, see figures 8, 9; claims 1,34; cited in the application --	1 10
Y	US,A,3648470 (SCHULTZ) 14 March 1972, see figures 1-3; claims 1-3; cited in the application --	1
A	Patent Abstracts of Japan, Vol. 11,No.110 (E-496)(2557) 07 April 1987, & JP,A,61259580 (CHINO WORKS LTD) 17 November 1986 cited in the application --	1
A	US,A,4677416 (YAMATAKE-HONEYWELL) 30 June 1987,see figure 1; claims 1,4,5 cited in the application --	1
A	US,A,3554815 (DU PONT DE NEMOURS) 12 January 1971 see claims 1-3 cited in the application ----------	1,3

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
17 May 1989 (17.05.89)	09 June 1989 (09.06.89)
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. EP 8900152 SA 26838

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 06/06/89
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 1381001	22-01-75		
US-A- 3648470	14-03-72		
US-A- 4677416	30-06-87	JP-A- 61124859	12-06-86
US-A- 3554815	12-01-71	CH-A- 413018 FR-A- 1409754 GB-A- 1021486	

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